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ABSTRACT

Cognitive flexibility is indispensable for applying knowledge to new situations. The development of this ability depends on certain conditions such as the attainment of a deep comprehension of the subject matter and the exposure to different knowledge representations. This paper focuses on these conditions and describes a study designed to foster the development of cognitive flexibility in a World Wide Web course. The Web-based literary studies course was developed to support the study of a novel, "Cousin Basilio," that describes the social life in Lisbon in the 19th century. In the Web course developed, "Cousin Basilio: Multiple Thematic Criss Crossings," nine themes were identified for approaching the novel. The novel has 16 chapters that were grouped to constitute the cases. Each case was divided into small parts, or mini-cases. Then relevant themes to each mini-case were identified and thematic commentaries were written. After the selection of a theme (or a combination of themes), thematic criss-crossing guides the user through a sequence of mini-cases and thematic commentaries to which the selected theme applies. This study evaluates how much the course structure contributes to the development of cognitive flexibility. Participants were 28 third-year undergraduate students enrolled in Portuguese Literature, 3 males and 25 females ranging from 19 to 27 years old. Results provide evidence on effectiveness of the deconstruction process to develop cognitive flexibility. (Contains 11 references.) (AEF)

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How To Develop Cognitive Flexibility In A WWW Course

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Abstract

Cognitive flexibility is indispensable for applying knowledge to new situations. The development of this ability depends on certain conditions such as the attainment of a deep comprehension of the subject matter and the exposure to different knowledge representation. This paper focuses on these conditions and describes a study designed to foster the development of cognitive flexibility on a World Wide Web course.

Cognitive flexibility

Cognitive flexibility is the ability to change one's perspective, to categorize data and stimuli according to different properties, to find new connections among the elements of a whole and to interpret the same reality in different ways. It is also the ability to recombine elements of a representation, or to reorder the importance of elements in different contexts (Spiro et al., 1987). Flexibility in thinking allows subjects to move from one category to another and to modify their point of view (Guilford, 1967).

Spiro & Jehng (1990: 165) state: "by cognitive flexibility, we mean the ability to spontaneously restructure one's knowledge, in many ways, in adaptive response to radically changing situational demands". Moreover, "this is a function of the way knowledge is represented (e.g., along multiple rather single conceptual dimensions) and the processes that operate on those mental representations (e.g., processes of schema assembly rather than intact schema retrieval)". According to these authors cognitive flexibility depends on the way knowledge is represented. Bearing this in mind, next session focuses on knowledge representation, particularly on complex knowledge representation.

Knowledge representation

The representation of complex knowledge, according to several authors, has to avoid compartmentalization, simplification, and a single dimension of analysis (Barthes, 1970; Morin, 1990; Spiro et al., 1991). Multiple dimensions of analysis are necessary for developing cognitive flexibility that depends of having a diversified repertoire of ways of thinking about a conceptual topic.

"Interpréter un texte, ce n' est pas lui donner un sens (plus ou moins fondé, plus ou moins libre); c' est au contraire apprécier de quel pluriel il est fait" (Barthes, 1970: 11).

Cognitive Flexibilitty Theory (CFT) proposes principles that help to develop cognitive flexibility (Spiro & Jehng, 1990), such as "knowledge deconstruction" and "thematic criss-crossing". At this point it is important to stress that this theory is case-based. A case represents specific knowledge tied to a context. It may be a chapter of a book, a few frames of a film, an event. Cases may have different shapes and sizes, covering large or small time slices (Spiro & Jehng, 1990; Kolodner, 1993; Kolodner & Leake, 1996). Each case has to be divided in small parts, called mini-cases. Each mini-case is analyzed according to multiple dimensions or multiple perspectives: the themes.
Themes are synonymous of principles or rules and they help to understand the complex knowledge. Each perspective or theme gives a new insight into the mini-case comprehension.

According to CFT there are two important paths to develop cognitive flexibility: "knowledge deconstruction" and "thematic criss-crossing". In the next section we describe the two paths illustrating them with an example: the web document "Cousin Basilio: multiple thematic Criss Crossings" (available at the following URL: www.iep.uminho.pt/primobasilio), ", for literary studies, we select a 19th century novel, "Cousin Basilio" written by Eça de Queirós.

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Two complementary ways of knowledge representation to promote cognitive flexibility

Knowledge deconstruction

The notion of *knowledge deconstruction* is shared by R. Barthes, J. Derrida and R. Spiro and it stresses the importance of multiple perspectives to deeply understand a subject matter. According to CFT the process of knowledge deconstruction implies the selection of *themes* and *cases*. The case is divided in small parts, the mini-cases. For each mini-case it is necessary to identify the relevant themes. Then, for each applied theme a "Thematic Commentary" has to be written, explaining how each theme applies to the particular mini-case. This text (thematic commentary) should state clear ideas in a simple language and it should be short to be easily read in a computer screen (see figure 1).

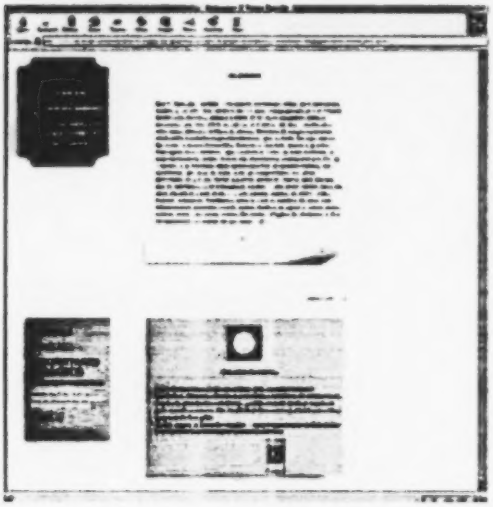

Figure 1 - Mini-case and Thematic Commentary of "Cousin Basilio"

In the web course that we developed "Cousin Basilio: multiple thematic Criss Crossings", we identified nine themes to approach the novel. This novel has sixteen chapters that we grouped to constitute the cases (table 1). Each case was divided in small parts, the mini-cases. Then, we identified the relevant themes to each mini-case and we wrote the thematic commentaries (see table 1).

For example, four themes apply to the first mini-case of Case I (see figure 1). The Thematic Commentaries related to each of these themes, give different and complementary insights to the text. On figure 1, one can see, on the right side, a mini-case and below it the text of the first Thematic Commentary.

Chapters	Cases	Mini-Cases	Thematic Commentaries
I - III	I	8	37
IV - V	II	7	37
VI - VII	III	6	35
VIII - XIII	IV	9	36
XIV - XVI	V	4	15
Total	-	34	160

Table 1 – Components of the process of deconstruction of "Cousin Basilio"

As "Cousin Basilio" action is carried out in the 19th century, for each mini-case we included information about the epoch. This information focuses on clothes, furniture, transportation, writers, composers, operas or novels mentioned in the mini-case. This information includes not just text but also pictures and video clips.

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Flexibility in applying knowledge depends on mini-cases being deconstructed (through themes and thematic commentaries; the user attains a deep understanding of that mini-case) and it also depends on rearranged structural sequences from different points of view or perspectives (thematic criss-crossings). Knowledge that have to be used in many ways has to be learned, represented and tried out in many ways.

Thematic criss-crossing

The process of *thematic criss-crossing* is inspired in Ludwig Wittgenstein' book "Philosophical Investigations". According to Spiro & Jehng (1990), Cognitive Flexibility Theory generalizes Wittgenstein's metaphor of the criss-crossed landscape. The authors explained that "by criss-crossing topical/conceptual landscapes, highly interconnected, web-like knowledge structures are built that permit greater flexibility in the ways that knowledge can potentially be assembled for use in comprehension or problem solving" (Spiro & Jehng, 1990: 170).

After the selection of a theme (or a combination of themes), thematic criss-crossing guides the user through a sequence of mini-cases (of different cases) and thematic commentaries to which the selected theme applies. For example, figure 2 exemplifies the process of thematic criss-crossing. In that example it is used the first traversal: "Denouncement of decadence". The sequence presented to the user does not have to respect the cases sequence (figure 2), but it has to be meaningful and give a deeper and multifaceted understanding of the theme.

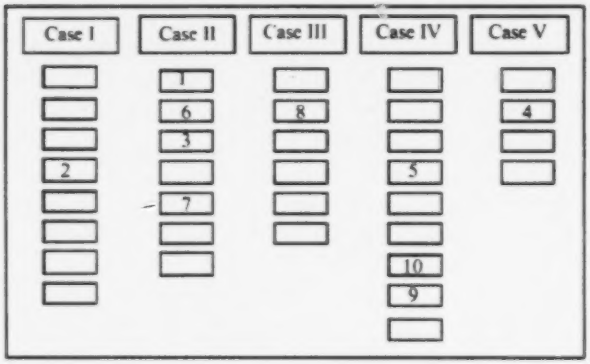

Figure 2 - Thematic Criss-Crossing (Denoucement of decadence)

"The same content material is covered in different ways, at different times, in order to demonstrate the potential flexibility of use inherent in that content" (Spiro et al., 1988: 379).

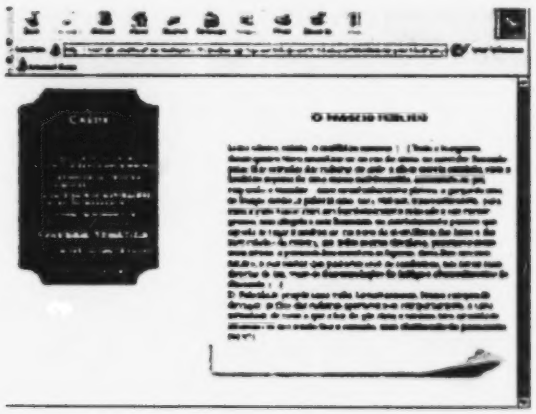

Figure 3 - Thematic Criss-crossing (mini-case)

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Both processes are complementary in the kind of learning promoted, and they have to be explored alternately. As users explore the mini-cases and the thematic criss-crossings, they will be familiar with some mini-cases that they can read for different purposes. Bearing this in mind we decided to use the bold style to give evidence to several expressions, sentences or words that are relevant to the thematic criss-crossing (see figure 3). In a glance the user identifies the mini-case, then he/she will focus on the bold text.

The importance of cognitive flexibility to knowledge transfer to new situations

Transferring knowledge to new situations is a very demanding task. This level of transfer is considered to be the most difficult and is referred to as "far transfer" (Gick & Holyoak, 1987). It is necessary to master a subject and have the ability to restructure the knowledge to fit or solve the new situation, e.g., it is necessary to have cognitive flexibility. The mentioned authors consider also two other levels of transfer: "self transfer" or knowledge reproduction and "near transfer" where there is a similarity between the new situation and others analyzed.

Structure of the World Wide Web Course

We developed a literary studies course in the web to support the study of a novel, "Cousin Basilio", that describes the social life in Lisbon in the 19th century (http://www.iep.uminho.pt/primobasilio), as we mentioned above. During the design phase we took in attention the utilization of icons and colors that helped to recreate the 19th century ambience in the web document "***Cousin Basilio*: multiple thematic criss-crossings**". For example, the Thematic Commentary background is an ancient official Portuguese stationery and the mini-cases background represents an old (yellow) page, inviting the user to pursue due to its slightly rolled page on the right corner (figure 1).

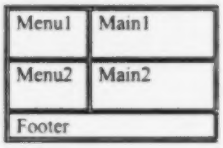

Figure 4 - Web site areas

The web pages are structured according to three main areas (figure 4). From top to bottom, we have the Menu 1, that is the Main Menu. If we select an item on this menu the information will be available on the Main 1 (figure 1). Then, on the area below, we have the Menu 2. This menu is dynamic because the items available on this menu depend on the options selected on the Menu 1. The item selected on the Menu 2 will be available on the Main 2 (see figure 1). The last area is called footer, and besides copyright information and e-mail address, there is also the possibility of the user to write his/her personal notes, clicking on the pen (see figure 5).

The menu 1 offers four options: *Cases* (knowledge deconstruction); *Thematic Criss-Crossing; Search;* and *Table of Contents*. On the menu 2 we have access to "*thematic commentaries*", information about the *Context* of the 19th century and about the text (mini-case) of the novel, and a general description about the nine *Themes* selected for approaching the novel. Some mini-cases have pictures that help to understand Lisbon scenarios or some ancient transportation or even some ancient furniture that helps to recreate and understand that century. Other mini-cases have a video that presents information about the novel. Finally, at the end of Menu 2, we have *References*, listing all authors mentioned in "thematic commentaries" or in the general description of Themes.

Instructions are provided to the user each time he/she selects an item (path) on the Menu 1. These instructions in blue simulate well-designed handwriting (figures 5 and 6).

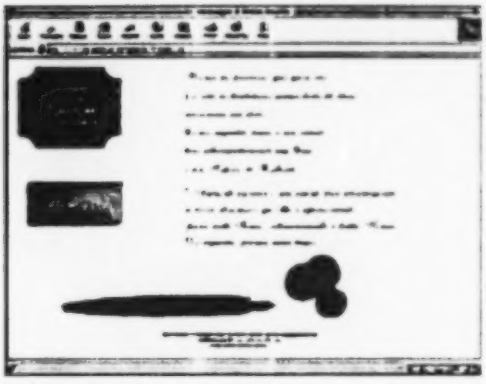

Figure 5 - Instructions to the user

Figure 6 - Search (cases and themes)

The home page has an image of an ancient book. It gives access to the Help page. On this page, one may obtain information about the approach used to the novel and about the options available on both menus. If the coins are pressed, one has access to the login page (figure 7). User name and password will be required. This document is access free, however, the password is needed to save one's own notes (during a month from last access). Feel free to look. These web pages are discrete and simultaneously appealing. Most of the web courses available have a high text density , which is not motivating for the user! Why aren't we exploring the web multimedia potentialities?

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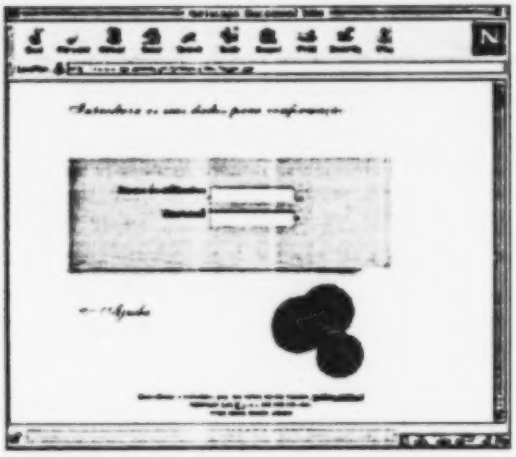

Figure 7.- User name and Password (access free)

The study

In this study we evaluate how far the course structure contributes to the development of cognitive flexibility. We use two groups and two different documents. One of the documents gives access to all CFT facilities (named CFT) and the other one does not have access to Thematic Commentaries (named NTC - No Thematic Commentaries), but only to the applied themes to each mini-case.

We developed several instruments to collect data such as knowledge tests (for measuring far, near and self-transfer questions); Questionnaires of Opinion to collect users' opinions about the web document design and structure and their orientation on it, path preference and involvement experienced, a Questionnaire on computer literacy and about user's motivation to participate in this study, and a final report about this study and their opinion about web courses for further learning.

As a pre-requisite for this study, subjects should be Portuguese Literature undergraduate students and they have had to read the novel "Cousin Basilio". Subjects received three packages along the course, containing instructions for the sessions on the web; knowledge tests: pre-test, intermediate test and post-test and Questionnaires of Opinion about the WWW course, and a Questionnaire on Computer Literacy.

When they finished the first package (Pre-test, Questionnaire on Computer Literacy), they contact the researcher for a session in the lab. This session intends to help subjects to feel comfortable to use and explore the web document. At the end of this session, students took the second package. As soon as they finished, the last package was sent to each one. Finally when they sent this one they received the questions for writing the final report.

Sample characterization

Twenty eight 3rd year undergraduate students enrolled in Portuguese Literature participated in this study. three males and twenty-five females, ranging from nineteen to twenty-seven years old. According to the information collected by the Questionnaire on Computer Literacy, we realized that most of the subjects (79%) never explored an interactive environment such as CD-I or CD-R. Only 12 subjects had explored the Internet. They mentioned different kinds of motivation for participating in this study, but the most referred ones were: to participate in a distance learning web course, to participate in this study due to their interest in literary work, or due to their interest in Eça de Queirós' literary work.

Results and discussion

We used non-parametric tests, specifically Mann-Whitney U test. The knowledge tests measure three kinds of transfer: self transfer or reproduction, near transfer and far transfer (Gick & Holyoak, 1987). The kinds of transfer that measure cognitive flexibility are near and far transfer. This last one is the most difficult and demanding kind of transfer.

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Pre-test	CFT	NTC	Z corrected for ties	Statistical significance
Total	15.19	13.58	-.511	p=.6091 NS
Reproduction	14.59	14.38	-.071	p=.9434 NS
Near transfer	15.44	13.25	-.699	p=.4846 NS
Far transfer	14.48	14.04	-.260	p=.7951 NS

Table 2 - Pre-test statistical analysis (Mann-Whitney U test)

Pre-test results show that there is no statistically significant difference (p=.6091), the groups are similar before being submitted to treatment (table 2).

Intermediate test	CFT	NTC	Z corrected for ties	Statistical significance
Total	18.03	9.79	-2.62	p=.0087 S
Reproduction	14.75	14.16	-.186	p=.8531 NS
Near transfer	17.87	10	-2.51	p=.0121 S
Far transfer	18.12	9.66	-2.71	p=.0066 S

Table 3 - Intermediate test statistical analysis (Mann-Whitney U test)

During this study, students have done an intermediate test. Results pointed out to statistically significant difference achieved in the test ($p<.05$) as in near and far transfer questions. There is no statistically significant differen.. in the reproduction questions, perhaps because the knowledge to be applied to these questions was the same on both documents.

Post-test	CFT	NTC	Z corrected for ties	Statistical significance
Total	18.12	9.67	-2.69	p=.0071 S
Reproduction	14.50	14.50	0	p=1 NS
Near transfer	17.66	10.29	-2.35	p=.0189 S
Far transfer	17.12	11.00	-2.02	p=.043 S

Table 4 - Post-test statistical analysis (Mann-Whitney U test)

Post test results show that there is statistically significant difference (p=.043) that gives evidence to the development of cognitive flexibility on the group of subjects exploring the CFT web document. This result shows the importance of thematic commentaries on knowledge transfer to new situations (table 4). CFT group has better results in near and far transfer questions. As on the previous test, both groups achieved similar results in these question, p=1.

Most of subjects (66%) considered the session in the lab indispensable and 34% of subjects considered that the information available on "help" was clear enough to explore the document. In what concerns users' opinion about the web document, 58% considered it "accessible to use" and 42% considered it "easy" to learn to use. On the first session, most of them (58%) felt oriented in the web document and 37% felt disoriented; on the following sessions all feel oriented, excepted one subject who felt disoriented.

Most of them (84%) considered the reading proposed to the novel "interesting" and 16% considered it "acceptable". They mentioned that they (95%) felt actively involved in this learning process. Their preferred path is the deconstruction process (Cases).

Subjects' opinion about web courses for further learning is a positive one (74%), however some would prefer a combination of face-to-face meetings and distance learning.

Conclusion

The knowledge representation used in this study to promote cognitive flexibility gives emphasis to knowledge deconstruction and to thematic criss-crossing. This complementary approach to complex knowledge representation used by Cognitive Flexibility Theory led us to study what is the importance of "thematic commentaries" (this is the focus of the deconstruction process) in learning and in cognitive flexibility. Results give

evidence to the deconstruction process to develop cognitive flexibility, i.e., to the importance of "thematic commentaries" to knowledge transfer to new situations.

Although subjects' computer literacy was low they felt it was easy to use the web document and to navigate in. They liked its design and structure.

They are receptive to participate in web courses for further learning, but some would prefer a combination of face-to-face meetings and distance learning.

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